Abstract—Wireless ad hoc networks becomes a new type of wireless networks gradually because it could communicate to each other without infrastructure base stations. Due to limited power, routing path is broken easily, so how to design an effective power saving routing protocol is an important issue in wireless ad hoc networks. To solve this issue, we propose a new routing protocol called power saving routing protocol with power sieving (PSRPS) in this paper. The proposed protocol partitions the network area into several square grids by the location information such as global position system (GPS). Routing is performed in a grid-by-grid manner. One node is elected as the grid leader in its grid with power sieving mechanism without broadcasting election packets. Therefore, nodes could save more power for data transmission and the network lifetime could be prolonged. The simulation results demonstrate PSRPS could reduce power consumption from 10% to 18% compared with the traditional grid-based routing protocol.

Keywords- wireless ad hoc networks; power sieving; grid; election packet; network lifetime

I. INTRODUCTION

Wireless ad hoc networks had attracted a lot of attention recently. It is consisted of a set of mobile nodes which could communicate with one another through multiple hops without infrastructure base stations. The packets sent by the source node are relayed by several intermediate nodes before reaching the destination node [1-2].

Due to the battery technology is not likely to progress as fast as computing and communication technology, designing the power saving routing protocols to construct power-efficient routings becomes an important issue [3-7]. In [8], a protocol’s behavior does have significant impact on power consumption. So a node should tune its wireless interface card into the doze mode whenever the node will not hurt its own and the network’s performance.

Among the existing routing protocols, grid-based routing protocol is often used for power saving by tuning the nodes into the doze mode [7, 9, 10]. In grid-based routing protocol, a node is elected as the grid leader in its grid. Routing is conducted in a grid-by-grid manner through grid leaders. Only the grid leaders keep in the active mode. Other nodes could be tuned into the doze mode to save power without hurting the network connectivity. However, when the battery power of grid leader is not sufficient to transmit packets, each node is tuned into the active mode by sending control packet to be elected as a new grid leader. In such situations, nodes consume the unnecessary power without data transmission and the routing lifetime is decreased.

For the above issues, we propose power saving routing protocol with power sieving (PSRPS) in this paper. In PSRPS, only partial nodes are tuned into active mode to be elected as the grid leaders by power sieving. Other nodes are kept in the doze mode. Hence, PSRPS could save power for transmitting packets and prolong the lifetime of network.

Simulation results are presented to demonstrate the efficiency of our proposed protocol. The rest of the paper is organized in the following sections. Section 2 presents the review of existing grid-based routing. Our scheme is stated in section 3. Section 4 discussed the simulation results. Final, the conclusions are made in section 5.

II. RELATED WORKS

Grid-based routing protocol is a geographic routing protocol based on grid architecture. It partitions the network area into several square/hexagon grids by the location information such as global position system (GPS) [7, 9, 10, 11]. Routing is performed in a grid-by-grid manner. One node is elected as the grid leader in its grid. The responsibility of grid leader includes: (i) forwarding routing discovery requests to neighbor grids, (ii) propagating data packets to neighbor grids, and (iii) maintaining routing which pass the grid. The other nodes which are not the grid leaders are not responsible for these jobs unless they are destinations of (i) and (ii), and sources/destinations of (iii). To reduce unnecessary collisions, the communication is divided into intra-grid and inter-grid. The routing discovery and maintenance could be modified from any of following protocols: source routing and next-hop routing [1-2].

However, most grid-based routing protocols focus on routing discovery and maintenance. To address the power issue, FPALA is proposed [9-10]. FPALA is a power-aware grid-based routing protocol based on GRID [11]. It proposes a power mode management mechanism for grid leader election to save power. In FPALA, a node with the maximum battery power is elected as the grid leader. The nodes which are not the grid leaders could be tuned into the doze mode without hurting the connectivity of the network. So the nodes could save power and the routing lifetime is prolonged.
However, new grid leader is elected by broadcasting the election packets in the traditional grid leader election. Each node is tuned into the active mode in a period time for registration. Hence, nodes consume more power without transmitting or receiving the data, and the routing lifetime is decreased. To solve the above issues, power saving routing protocol with power sieving is proposed in this paper.

In our proposed routing protocol, only few nodes of the grid are tuned into the active mode to join in the grid leader election when the battery power of old grid leader is insufficient for transmitting packets. Other nodes could be tuned into the doze mode to save power for data transmission.

III. POWER SAVING ROUTING PROTOCOL WITH POWER SIEVING

Power saving routing protocol with power sieving is a kind of power-aware and location-aware grid-based routing protocols in wireless ad hoc networks. It virtually partitions the network area into several square grids by GPS. One node of the grid is elected as the grid leader. The routing is performed in a grid-by-grid manner through grid leaders, and divided into intra-grid and inter-grid communications. In PSRPS, we define \( d = (\sqrt{2}/3)r \), where \( d \) and \( r \) denote the side length of grid and the transmission distance of a radio signal, respectively [11]. In this definition, a grid leader located at the center of a grid is capable of talking to any grid leader of its 8 neighbor grids as shown in Fig. 1.

![Image](330x495 to 332x578)

**Figure 1. The relation between d and r**

### Routing discovery and maintenance

In our proposed protocol, routing is conducted in two levels: inter-grid and intra-grid. The former is supported by the point coordination function (PCF) of IEEE 802.11 and the latter is supported by the distributed coordination function (DCF) of 802.11. The time axis is divided evenly into a sequence of superframes for all nodes participating in the networks from FPALA [9-10]. The inter-grid and intra-grid routings are under the superframe as shown in Fig. 2.

![Image](340x520 to 344x543)

**Figure 2. Superframe**

For intra-grid communication, if a packet is targeted at a node resident in the same grid, it is sent to that node directly by its grid leader during the intra-grid phase. For inter-grid communication, a packet is forwarded in a grid-by-grid manner during the inter grid phase. In inter-grid routing, a routing could be modified from any of the following protocols: source routing and next hop routing. Because the route discovery could be done following the protocols in [11], we do not further elaborate. In our proposed protocol, we adopt the AODV protocol [2] as our routing discovery procedure as shown in Fig. 3.

![Image](342x483 to 346x513)

**Figure 3. AODV**

### Grid leader election and maintenance by power sieving

In grid-based routing protocols, the grid leader is responsible for routing, relaying packets, and maintaining the correct operation of grids. So an efficient grid leader election and maintenance is needed.

In the traditional grid leader election and maintenance, all nodes in a grid are tuned into active mode to be elected a leader when the battery power of grid leader is insufficient for transmitting packets. However, some nodes of the grid consume unnecessary power in the grid leader election and maintenance because the battery power of these nodes is lower than the battery power of others in the grid.

Therefore, we propose a grid leader election and maintenance by power sieving (GLEMPS) to replace the traditional grid leader election in PSRPS. In GLEMPS, we define a threshold value of grid leader election (\( E_{Glb} \)) and of grid leader alternation (\( E_{Gl} \)). When the battery power of grid leader is less than \( E_{Glb} \), each node in a grid compares its battery power with \( E_{Glb} \). While the battery power of node is larger than \( E_{Glb} \), the node is tuned into the active mode and joins in the grid leader election, otherwise the node is tuned into the doze mode. Hence, only the few nodes of in the grid join in the grid leader election and other nodes are kept in the doze mode to save power.

The process of GLEMPS is as follows:

1. Initially, the node \( i \) compares \( E_i \) with \( E_{Glb} \). While \( E_i \) is larger than \( E_{Glb} \), node \( i \) broadcasts a BID(\( gid, id, E_i \)) packet, otherwise it is tuned into the doze mode,
where \( \text{gid}_i, \text{id}_i, \) and \( E_i \) are the grid coordinates, the node identity and the battery power of node \( i \), respectively.

2. While the node \( j \) receives the BID packet, it compares \( E_j \) and the \( E_i \) of the BID packet. If \( E_j \) is larger than the \( E_i \) of the BID packet, the node replaces \( E_i \) with \( E_j \) of the BID packet and broadcasts the BID packet to other nodes, otherwise it stops broadcasting it.

3. When the last node does not sense the BID packet for a predefined time, the node transfers itself into grid leader and broadcasts its existence by sending a GATE\((\text{gid}_i, \text{id}_i, \text{NT}, \text{RT})\) packet to other nodes of its grid, where \( \text{NT} \) is the neighboring grid leader table and \( \text{RT} \) is the routing table.

4. Each node sends a REG\((\text{gid}_i, \text{id}_i)\) packet to grid leader for registration in a period time.

5. While the grid leader does not receive the REG packet for node \( i \), it removes node \( i \) from \( \text{NT} \).

6. While the \( E \) of grid leader is less than \( E_{\text{th}} \), the grid leader broadcasts a RETIRE\((\text{gid}_i, \text{id}_i)\) packet to the nodes of its grid where \( E \) denotes the battery power. Afterwards, GLEMPS restarts to elect a new grid leader.

To avoid no grid leader is elected in the grid leader election. When no grid leader is elected in a predefined time, let \( E_{\text{Gth}} = E_{\text{Gth}} \times 0.9 \) and restart GLEMPS.

Assume \( M, N_{\text{node}}, E_{\text{total}}, \) and \( E_{\text{ele}} \) are the number of election, the number of nodes, power consumption of all elections, and power consumption of the node in an election, respectively. \( P_i \) is the probability of the node joining in the \( i \)th election. We derive the equation as (1).

\[
E_{\text{total}} = \sum_{i=1}^{M} N_{\text{node}} \times P_i \times E_{\text{ele}} \quad (1)
\]

In FPALA, \( P_i \) is always 1. So \( E_{\text{total}} \) of PSRPS is less than or equal to \( E_{\text{total}} \) of FPALA. It proves that PSRPS reduces more power consumption than FPALA.

**IV. SIMULATION RESULTS**

The simulation area is conducted on \( 10 \times 10 \) square grids within an area of \( 1000 \times 1000 \) m\(^2\). Set the side length of grid to be \( d = 100 \) m and the node’s maximum transmission distance to be \( r = 150\sqrt{2} \) m. The data rate is 11 Mbit/s (IEEE 802.11b). The transmission mode is CBR (20 packets/s). The size of packet is 1500 bytes. Each superframe length is 200 ms. The leader phase occupies 1 ms and the maintenance phase occupies 4 ms. The length ratio of the intra-grid phase to the inter-grid phase is 1:4. The initial battery power of the node is 40 J. \( E_{\text{th}} \) is 10% of the initial battery power. The active, monitor, and doze modes consume 280, 70, and 10 mW, respectively [7, 9, 10]. When the grid leader election is begun, the number of grid leader alternation \( (N_{\text{alt}}) \) is increased by 1.

We evaluate the total power consumption under PSRPS and FPALA. The total power consumption denotes the accumulative power consumption by all nodes in the routing. When the quantity of node is 20, the total power consumption of PSRPS is 10% less than FPALA as shown in Fig. 4. When the quantity of node is 30, the total power consumption of PSRPS is 18% less than FPALA as shown in Fig. 5.

**V. CONCLUSIONS**

Due to the limited power of the node, designing an efficient power saving routing protocol becomes an important issue in wireless ad hoc networks. To address the issue, many power-
aware routing protocols are proposed. Among these protocols, grid-based routing is the general solution for power saving. In grid-based routing, nodes could be tuned into the doze mode to save power. However, the traditional grid-based routing protocols consume redundant power on our paper survey.

To solve this issue, power saving routing protocol with power sieving (PSRPS) is proposed in this paper. In PSRPS, the partial nodes join in the grid leader election to be elected as the leader and other nodes are tuned into sleep mode to save power. Therefore, PSRPS could save more power in the grid leader election and maintenance. Moreover, PSRPS reduces more power consumption when the density of nodes is increased by the simulation results.

In this paper, we use AODV as our routing procedure and the node is stationary. So we will make the nodes mobile and integrate other routing protocols with our proposal for more analysis and improvements in the future.

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REFERENCES


